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UTILIZATION OF FISHERY BY-PRODUCTS IN WASHINGTON AND OREGON*

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Abstract

This is a survey of the status of the fishery by-products industry in Washington and Oregon. Fish waste is utilized as the whole waste or is separated into its various components and selected portions utilized. The whole waste is used in fish hatcheries, on fur farms, in pet food, and in reduction plants. The selected portions used are the skins, eggs, and livers and viscera. The skins are processed for manufacture into leather for women's shoes; the eggs are made into caviar and fish bait; and the livers and viscera are rendered for oil and vitamin A. The most important producting areas in Washington are Puget Sound, Grays Harbor, Columbia River, and Willapa Harbor. In Oregon, the Astoria-Warrenton-Hammond area is the center of greatest production. Also important are Yaquina Bay, Coos Bay, and Tillamook Bay.

Introduction

This report is a survey of the fishery by-products industry in Washington and Oregon. Raw materials for this industry are, of course, supplied by the commercial fishery. Data on the species of fish (and shellfish) available are given in Tables 1 and 2.

In the State of Washington during 1947, the latest year for which complete data are available, salmon accounted for nearly 50 percent of the weight of fish landed and for nearly 60 percent of the fishermen's income. These data, however, are not entirely typical. For example, 52 million pounds of the total production was due to an unusually heavy run of pink salmon. Again, 1947 was abnormal inasmuch as a prolonged strike by the fishermen greatly reduced the amount of halibut landed. The data for any one year in an industry that fluctuates as greatly as does fisheries will necessarily be somewhat atypical. Nevertheless, the quantities given in Table 1 suffice to show, in general, the relative importance of the various species.

The fishery in Oregon is quite similar to that in Washington. A comparison of Tables 1 and 2 shows that of the 10 species of fish landed in largest quantities in Oregon in 1947, 7 of the species (salmon, grayfish, crab, flounders, rockfish, lingcod, and albacore) were among the 10 species landed in largest quantities in Washington. Of the 5 species of greatest dollar value to the fishermen of Oregon, 3 of the species (salmon, crab, and albacore) are among the 5 species of greatest value to the fishermen of Washington. In both of the 2 States, salmon furnish the fishermen with the greatest relative amount of their income.

Table 1 - Commercial fishery production in the State of Washington during 1947

Species	Weight	Value
	Pounds	Dollars
Salmon	84,121,000	13,600,000
Grayfish[1]	15,282,000	974,000
Crab	11,973,000	1,081,000
Oysters	11,382,000	2,110,000
Flounders	9,331,000	522,000
Halibut	7,829,000	1,710,000
Rockfishes	6,707,000	296,000
Lingcod	4,827,000	552,000
Albacore	4,243,000	1,141,000
Cod	3,112,000	125,000
Sablefish	2,966,000	413,000
Pilchard	2,850,000	78,000
Smelt	1,993,000	128,000
Ratfish	1,363,000	20,000
Herring	1,195,000	43,000
Clams	1,152,000	425,000
Soupfin shark[2]	583,000	429,000
Miscellaneous[3]	1,999,000	160,000
Total production	172,903,000	23,807,000

1/ These sharks were caught for their vitamin A-rich livers; only about a million pounds of carcasses were landed.

2/ These sharks were caught for their vitamin A-rich livers; none of the carcasses was landed.

3/ Includes anchovies, hake, octopus, perch, scallops, shad, skates, squid, steelhead trout, sturgeon, and shrimp.

Table 2 - Commercial fishery production in the State of Oregon during 1947

Species	Weight	Value
	Pounds	Dollars
Salmon	20,631,000	3,817,000
Pilchard	13,871,000	260,000
Albacore	9,174,000	2,500,000
Crabs	7,532,000	655,000
Flounders	7,282,000	292,000
Rockfishes	6,822,000	212,000
Grayfish	2,824,000	204,000
Shad	1,590,000	95,000
Steelhead trout	1,459,000	238,000
Lingcod	813,000	60,000
Halibut	715,000	149,000
Soupfin shark	668,000	553,000
Sablefish	407,000	33,000
Sturgeon	291,000	60,000
Clams and oysters	187,000	52,000
Miscellaneous 1/	1,004,000	61,000
Total production	75,270,000 2/	9,241,000

1/ Includes bluefin shark, carp, cod, crawfish, hake, herring, perch, smelt, striped bass, and unclassified fish.

2/ Does not include the catch of tuna taken off Latin America and landed in Oregon. This catch amounted to 289,000 lbs. of skipjack valued at $42,000 and 3,121,000 lbs. of yellowfin valued at $484,000.

The most important producing areas in Washington are Puget Sound, Grays Harbor, Columbia River, and Willapa Harbor. They supplied respectively 74, 16, 6, and 4 percent of the fish landed. In Oregon the Astoria-Warrenton-Hammond area is the center of greatest production. Also important are Yaquina Bay, Coos Bay, and Tillamook Bay.

Of the various species of salmon taken in Washington, the pink (Oncorhynchus gorbuscha) is the most abundant, as judged by the catches of the years 1935 to 1947. The other species listed in descending order of relative abundance are sockeye (Oncorhynchus nerka), chinook (Oncorhynchus tshawytscha), silver (Oncorhynchus kisutch), and chum (Oncorhynchus keta). Steelhead trout (Salmo gairdnerii), often included with salmon, ranks last. A heavy pink salmon run occurs each odd numbered year, while an extremely light run occurs each even numbered year. In Oregon, the species of salmon listed in descending order of abundance, as determined by the 1947 catch, were chinook, silver, steelhead, chum, and sockeye (called blueback in the Columbia River Area).

The overall production for the two States totaled about 250 million pounds and gave the fishermen an income of about $33,000,000. By way of comparison, approximately 4.5 billion pounds of fish worth nearly $300,000,000 were landed in the United States and Alaska in 1948. About the same weight of fish was produced in the United States and Alaska in 1947. Although the approximately quarter billion pounds of fish landed in Washington and Oregon are small relative to the total production, they are important in dollar value because they contribute about 11 percent of the total income of all the American fishermen.

Utilization of Fish Waste

Fish waste is utilized as the whole waste or is separated into its various components and selected portions utilized. The whole waste is used in fish hatcheries, on fur farms, in pet food, and in reduction plants. The selected portions used are the skins, eggs, and liver and viscera. The skins are processed for manufacture into leather for women's shoes; the eggs are made into caviar and bait; and the livers and viscera are rendered for oil and vitamin A.

Food for hatchery fish

Fish hatcheries are one of the most important users of fish waste in respect to their conservational value to the fishing industry. The type of scrap used is largely decided by cost and availability, with salmon waste heading the list. See Tables 3, 4, and 5.

Two critical problems in hatchery management are the proper nutrition of fish and fish diseases. These two problems are apparently not independent. Presumably a fish that has been properly fed is better able to resist disease than is one that has been weakened by an inadequate diet. Although knowledge of the nutritional requirements of fish is increasing, it is still a difficult problem. Like the poultry farmer, the hatchery manager must feed a satisfactory diet at a reasonable cost. When the millions of dollars that have gone into research on poultry - feeding are compared with the relatively small sums spent in hatchery studies, it is not surprising that much has yet to be learned about the nutritional requirements of fish.

Table 3 - Data on hatchery food used by the Washington State Department of Fisheries in 1947

Kind of food	Amount used	Cost per pound	Total Cost
	Pounds	Cents	Dollars
Fish scrap and salmon viscera	272,600	2	5,452
Salmon carcasses	227,000	1	2,270
Beef liver	94,500	12.5	11,812
Beef spleen	18,900	9	1,701
Fish meals1/	10,000	7.5	750
Yeast	6,300	15	945
Total	629,300		22,930
Average		3.64	

1/ 10,000 pounds of fish meal represents about 50,000 pounds of raw fish waste.

Table 4 - Data on hatchery food used by the Washington State Department of Game in 1947

Kind of food	Amount used	Cost per pound	Total cost
	Pounds	Cents	Dollars
Fish	550,000	2.5	13,750
Beef liver	395,000	11	43,450
Salmon viscera	385,000	2	7,700
Beef spleen	300,000	8	24,000
Fish meal	265,000	6	15,900
Horse meat	180,000	8	14,400
Canned salmon	80,000	5	400
Beef lungs	55,000	4	2,200
Wet, miscellaneous	35,000	4	1,400
Dry, miscellaneous	17,000	10	1,700
Total	2,262,000		124,900
Average		5.45	

Table 5 - Data on hatchery food used by the Oregon Fish Commission in 1947

Kind of food	Amount used	Cost per pound	Total cost
	Pounds	Cents	Dollars
Salmon viscera	330,228	3.5	11,558
Salmon flesh	123,146	1	1,231
Bottom fish paste	83,700	4	3,348
Tuna viscera	52,895	3.5	1,851
Salmon pulp	31,960	3.5	1,118
Ground sole	14,260	3.5	499
Sole viscera	7,558	3.5	264
Herring	6,645	5	332
Salmon and halibut sawdust	6,130	3.5	215
Beef liver	5,432	12	652
Smelt	5,200	2	104
Wheat shorts, millrun	4,200	3.5	147
Rock viscera	2,400	3.5	84
Brewer's yeast	2,205	15.5	342
Fish eggs	1,913	5	96
Shad viscera	1,350	3.5	473
Ground shad	560	3.5	20
Kinney's fry food	450	12	54
Sturgeon viscera	180	2.5	5
Total	680,412		22,393
Average		3.29	

Rapidly changing conditions have accentuated the need for further study. A substitute for beef livers is needed. These livers supply certain vitamins and are especially valuable as a source of the anti-anemia factor. Fish can use, without ill effect, livers containing flukes which have been condemned as unfit for human consumption. Inasmuch as these livers can be obtained cheaply, it is practical to include them in the diet. However, due to recent advances in animal husbandry, the incidence of fluky livers in farm animals is decreasing. As a consequence, these livers are becoming difficult to obtain in adequate amounts. This is only one of many problems encountered in feeding hatchery fish.

The amount of food used by the hatcheries is considerable. In 1947 the Washington and Oregon State Agencies alone required 5.5 million pounds (Tables 3 - 6). When the needs of the private and federal hatcheries in these two states are included, the total figure is over 10 million pounds. Future requirements will be greater. The trend is to raise the fish to larger size before releasing them because it has been shown that the larger the fish are at the time of release the better the chances are for survival (Table 7). Additional food demands are also being created by the construction of new hatcheries and the expansion of existing facilities. It is contemplated that about 30 hatcheries will be built on the Columbia River alone. Since at present it is difficult to obtain

sufficient hatchery food, this problem may become critical in the near future.

Table 6 - Data on hatchery food used in the Oregon State Game Commission in 1947 1/

Total amount used	Average price per pound	Total cost
Pounds	Cents	Dollars
2,005,000	7.98	160,024

1/ Data in Tables 3 - 6 supplied by Dr. Lauren R. Donaldson, School of Fisheries, University of Washington.

Table 7 - Data on the age of silver salmon at the time of planting and the relative numbers surviving to migrate 1/

Age at the time of planting	Relative numbers surviving to migratory age
Months	Percent
3	10
6	22
9	45
12	75

1/ Data supplied by State of Washington, Department of Fisheries.

The immediate need is to work out an adequate method for handling the present supply of fish waste. Some portions are more nutritious than others; therefore the waste should be sorted. The waste should be quick frozen within 6 hours after it is taken from the fish. There must be adequate cold storage facilities to hold the frozen waste for long periods, since the waste is produced during only a relatively short time each year. All this must be accomplished at low cost.

With the growing dependence of the salmon industry on hatchery-reared fish, the whole problem of hatchery-fish nutrition merits serious attention.

Food for Fur Farm Animals

Fur farming has become an important industry in the Pacific Northwest and a factor in extending the utilization of fish waste. In Western Washington and Oregon, about 70 percent of the diet of animals on fur farms is composed of fish materials. Most of the early fur breeders in this area raised foxes. Now about 95 percent of the fur farms are devoted to raising mink.

Mink breed in March. The period of gestation varies from 44 to 60 days, and the young, called kits, are born during the latter part of May. The litters average 4 kits. The kits are weaned at approximately 6 weeks. At 3 months of age each kit consumes about half a pound of food a day. By November, it reaches full growth, and the fur is in prime condition. The majority of the pelting is done the last week of November, although some pelting may be continued during the first week of December. Not all the animals are pelted; about one-third are kept as breeding stock.

The heaviest demands for food are in August, September, and October. Only a small amount of salmon waste is used because it is believed to contain too much oil. The greatest demand is for the offal discarded in the filleting of bottom fish. This material is passed through a meat chopper, and is fed fresh, or is frozen and stored for use at a later period. The food must be strictly fresh. After the animals have been fed, any uneaten portions are removed. About 70 pounds of fish are required to raise a mink. This value includes the amount of food that is normally wasted.

In 1948, the price of mink pelts was low. The best quality dark male pelts averaged about $14 apiece, and the female pelts brought $7 to $10 each. The overall average was between $9 and $10 as compared to about $20 in 1946. Because of the present low prices, many farmers are faced with the prospect of going out of business. This does not necessarily mean, however, that there will be a great curtailment in the demand for mink food. As one of the Canadian farmers pointed out when interviewed in Bellingham where he was getting a truck load of scrap, those ranchers who stay in the business will have to raise more mink to make a living. Furthermore, there will be a tendency to use less horse meat, which is expensive, and to substitute fish waste. This particular farmer stated that his mink were being fed a diet containing 80 percent fish waste.

Figure 1 - Mink farmer collecting fish scrap at Astoria, Oregon

Pet Foods

Most of the pet foods manufactured in Washington and Oregon do not contain fish. Beef, poultry, and horse meat are the principal ingredients. Nevertheless, approximately a million pounds of fresh fish waste are used annually in the Pacific Northwest for this purpose. Fish meal is also used in pet foods.

Several of the manufacturers contacted in this survey had not previously considered the use of fish in their products.

Fish Meal and Oil

The production of meal and oil from marine sources is one of the oldest and most successful of the by-product industries. In the states of Washington and Oregon, the pilchard or Pacific sardine has been an important raw material used for reduction purposes. Unfortunately, the production of pilchard meal and oil has varied greatly due to large fluctuations in the abundance of fish. In the state of Washington during the years 1936 to 1947, the production of pilchard meal varied from a high of 4,633 tons in 1938 to a low of only 3 tons in 1944 (Table 8). The production of pilchard meal in Oregon shows equally large variations (Table 9).

Table 8 - Washington production of fish meal and oil, 1936 - 1947

Year	Pilchard meal	Other meal	Pilchard oil	Liver oil	Other oil	Total meal	Total oil
	Tons	Tons	Gallons	Gallons	Gallons	Tons	Gallons
1936	983	750	193,467	24,729	74,100	1,733	292,296
1937	2,871	1,139	824,332	30,599	122,300	4,010	977,231
1938	4,633	798	1,213,639	72,612	79,315	5,431	1,365,566
1939	3,227	864	673,186	47,467	92,550	4,091	813,203
1940	189	756	46,325	78,822	110,202	945	235,349
1941	3,324	1,323	407,513	255,955	136,653	4,647	800,121
1942	205	1,682	4,976	313,982	161,562	1,887	480,520
1943	1,481	1,389	235,950	226,808	107,180	2,870	569,938
1944	3	1,133	420	405,250	37,460	1,136	443,130
1945	437	3,354	67,792	278,520	194,187	3,791	540,499
1946	1,137	2,417	191,889	380,881	173,428	3,554	746,198
1947	256	2,063	51,210	261,866	147,505	2,319	460,581

Table 9 - Oregon production of fish meal and oil, 1936 - 1947

Year	Pilchard meal	Other meal	Pilchard oil	Liver oil	Other oil	Total meal	Total oil
	Tons	Tons	Gallons	Gallons	Gallons	Tons	Gallons
1936	2,426	193	470,836	-	26,457	2,619	497,293
1937	2,822	174	689,393	-	33,165	2,996	722,558
1938	2,941	241	718,830	-	38,468	3,182	757,298
1939	3,904	364	834,082	784	44,636	4,268	879,502
1940	587	555	111,940	14,005	58,919	1,142	184,864
1941	2,081	360	289,896	50,221	49,222	2,441	389,339
1942	153	420	8,450	23,234	60,782	573	92,466
1943	365	625	33,000	12,127	40,252	990	85,379
1944	1	1,679	220	4,593	71,525	1,680	76,338
1945	-	1,369	-	17,208	69,536	1,369	86,744
1946	725	637	118,860	11,340	56,673	1,362	186,873
1947	1,047	1,418	178,263	7,122	78,046	2,465	263,431

The trend of landings in recent years has been downward, not only in Washington and Oregon, but also in California and British Columbia. That the decrease should be noted over such a wide area is not surprising, since the pilchard travel up and down the Pacific Coast on feeding and spawning migrations. The cause of the decrease is not known for certain, but it appears that the annual recruitment has not been large since 1939 and 1940.

Scrap discarded in the canning of salmon, tuna, and crab, and in the filleting of bottom fish is an additional source of oil and meal. Also utilized are whole herring, grayfish (with livers removed), skates, ratfish, and other species not presently being marketed for food.

Fish meal is usually sold on the basis of its crude protein content, which varies from a low of about 26 percent for crab meal to a high of about 70 percent for herring meal. Price is governed also by quality, quantity, location of markets, and general market conditions. Table 10 lists quotations for April 26, 1949 for the various kinds of meal.

The trend of oil prices has been downward. In January 1949, sardine oil was selling for 11 cents a pound as contrasted with a price of 23 cents only a year earlier. By May 1949, the price had dropped to 6 cents.

Table 10 - Price quotations on April 26, 1949 for various fish meals

Type of meal	Locality	Concentration of protein 1/	Price per ton 2/	Price per protein unit per ton
		Percent	Dollars	Dollars
Tuna	Los Angeles, Cal.	60	210.00	3.50
Sardine	Los Angeles, Cal.	65	227.50	3.50
Sardine	San Francisco , Cal.	67	251.25	3.75
Herring	Portland, Ore.	70	259.00	3.70

1/ Calculated from data supplied by the United States Department of Agriculture.
2/ Small scattered offerings. Prices nominal.

Salmon Skin Leather

A recent development is the canning of salmon with the skin and backbone removed. The process has been made possible by the invention of a machine that does the skinning and boning. Another machine removes from the skin a thin layer that includes the fish scales. The remaining portion of the skin can be manufactured into a leather that is smooth, pliable, non-porous, and capable of being tanned and dyed. The salmon leather has the appearance of snake skin. It is finding a ready market in the manufacture of shoes for women.

The canning of salmon, with the skin and backbone removed, appears to be economically sound because four canneries in Alaska and one in the San Juan Island prepared such packs last year.

Caviar and Fish Bait

The cost of the segregation of salmon eggs is justified at the present time because the price is ten or more cents a pound. Hence, most of the eggs suitable for caviar or fish bait are now being utilized. This amounts to about two million pounds annually.

Salmon eggs vary in size and firmness, depending upon their maturity and the species of fish from which they are obtained. The eggs, as taken from the fish, are contained in a sac. They can be separated from each other by rubbing them over a screen of such mesh that the free eggs fall through. The immature eggs are difficult to separate because they break easily. Some markets for bait eggs require that the eggs be dyed a red color; others prefer that oil be added in place of the dye. Single large eggs are in demand for trout bait. Clusters are used in the preparation of bait for steelhead trout. Caviar is made from the smaller eggs since the large mature ones tend to be tough and lacking in flavor.

Vitamin A Oils

The development of the vitamin A industry in the Pacific Northwest is a dramatic example of the value of research. Prior to the discovery that the liver of the grayfish is a rich source of vitamin A, the liver oil was often used as a lubricant on skid roads. Today the grayfish are eagerly sought and have been so reduced in numbers that they are relatively difficult to catch. During the last 10 years, millions of dollars have been added to the income of the fishermen, and the small sum spent on the research which made this possible has been repaid many times.

The soupfin shark has been another important source of vitamin A. The liver of the soupfin is exceedingly rich in this vitamin and is valued up to $20 a pound. Shark fishermen, when lucky, have made thousands of dollars overnight. As a consequence, the fishing intensity has been high, and the soupfin shark have been greatly reduced in number. By restricting the catch to mature males, it is hoped that the fishery can again be made profitable.

The landings of the various types of fish livers and viscera in the States of Washington and Oregon for 1947 are given in Tables 11 and 12. The importance of grayfish and soupfin shark is evident. The true importance of halibut livers, however, is not clearly apparent because of a strike that reduced the number of halibut caught in the year 1947. The landings during a normal fishing season are about twice the figures given.

Table 11 - Landings of liver and viscera in Washington, 1947

Type of liver 1/		Amount landed	Value
Common name	Scientific name	Pounds	Dollars
Grayfish	Squalus suckleyi	1,834,000	967,000
Soupfin shark	Galeorhinus zyopterus	70,000	429,000
Halibut, lingcod, and sablefish viscera		460,000	216,000
Lingcod	Ophiodon elongatus	134,000	193,000
Halibut	Hippoglossus stenolepis	105,000	181,000
Sablefish	Anoplopoma fimbria	81,000	127,000
"Rockfish"	2/	10,000	10,000
Ratfish	Hydrolagus colliei	204,000	10,000
Codfish	Gadus macrocephalus	48,000	5,000
Skate	Raja sp.	25,000	1,000
Hake	Merluccius productus	1,000	3/
Total		2,972,000	2,139,000

1/ Raw material is liver except as otherwise noted.
2/ Rockfish, flounder, sole, etc.
3/ Less than $500.

Figure 2 - Picking liver from a petrale sole. Not many years ago, livers of this type were discarded. They are now a minor source of income.

Table 12 - Landings of liver and viscera in Oregon, 1947

Type of liver 1/	Amount landed	Value
	Pounds	Dollars
Soupfin shark	80,000	553,000
Grayfish	339,000	204,000
Lingcod	24,000	57,000
Halibut	9,000	15,000
Sablefish	9,000	7,000
"Rockfish" 2/	5,000	5,000
Halibut, lingcod, rockfish, and sablefish viscera	34,000	5,000
Blue shark	15,000	3,000
Total	515,000	849,000

1/ Raw material is liver except as otherwise noted.
2/ Rockfish, flounder, sole, etc.

At present, the synthetic product is a specter hovering over the natural vitamin A industry. Even now, a small amount of synthetic vitamin A is available, but the price is too high to cause immediate concern. What the future will bring is difficult to determine. It has been predicted that the price may ultimately drop to as low as nine cents or even as low as three cents a million units.

In general, however, the number of "viewers-with-alarm" are balanced by the number of optimists. Many of the latter believe that with a larger and more assured source of supply, the variations in production that have plagued the natural vitamin A industry will be smoothed out. They believe that potential buyers who have heretofore hesitated to develop a market because of the fluctuation in supply will be encouraged to do so.

Others find cause for optimism in the technological difficulties that certainly must attend the production of the synthetic vitamin, and because of the conservatism of many consumers who will hesitate to adopt a relatively untried product. Regardless of the future, research is being continued by the natural vitamin A industry, especially to find profitable uses for by-products; and conservation measures to assure an adequate supply of soupfin shark are being urged.

Fishing Centers

The preceding discussion has covered the general situation in the States of Washington and Oregon. However, conditions vary somewhat from one fishing center to another. The particular condition to be found in each of the more important fishing communities are given in the discussion as follows.

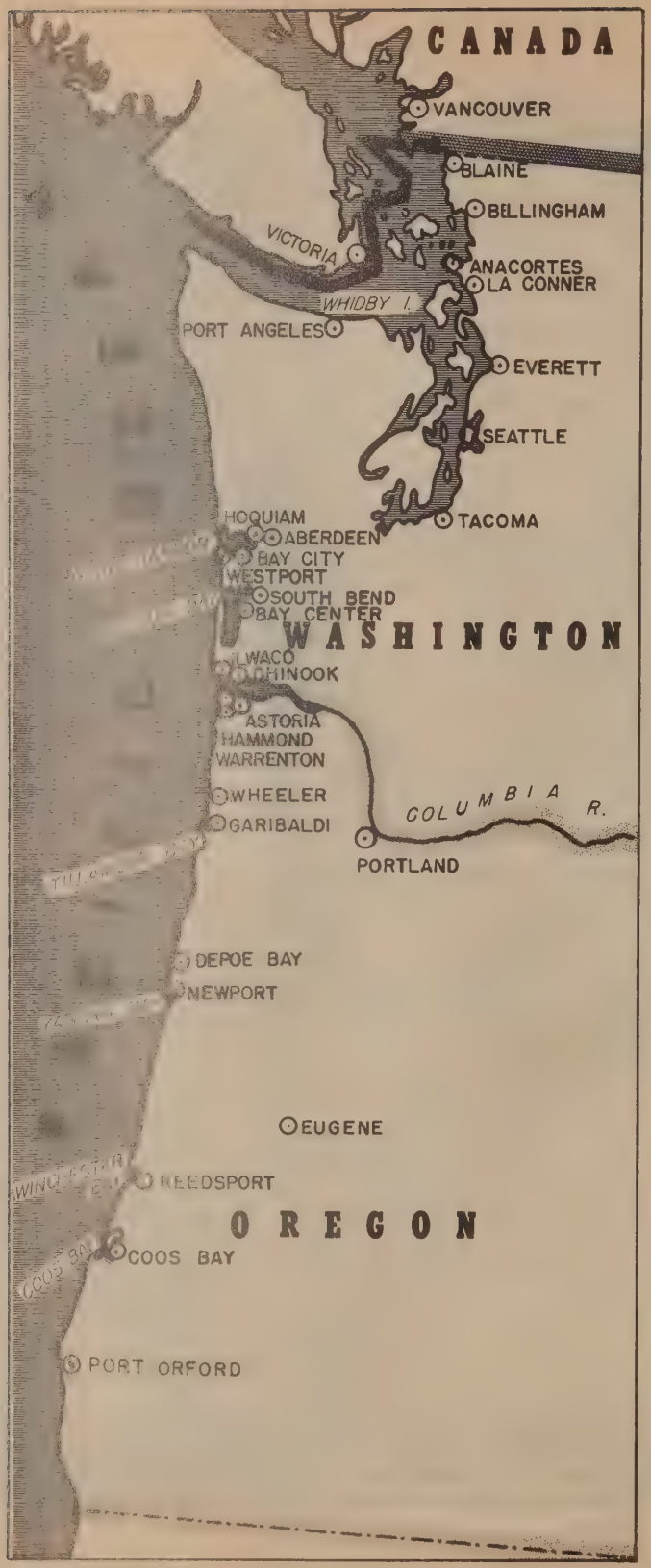

Figure 3 - Map of the Washington and Oregon area

Coos Bay, Oregon

Salmon and crab are the principal fishing industries in this area. The crab waste is discarded. The salmon eggs are sold for bait and a local salmon hatchery takes the rest of the viscera. Coos Bay is one of the two important oyster growing areas in Oregon.

Yaquina Bay, Oregon

Yaquina Bay is Oregon's second most important fishing center. Landed here are salmon, tuna, crab, and bottom fish. The salmon scrap is taken by a fish hatchery. Mink farmers living near the city use most of the fillet waste, and the excess is sold to ranchers in the Willamette Valley and elsewhere. With the exception of crab scrap, the waste not otherwise used is made into meal and oil by a local reduction plant. The crab scrap is not utilized because of the low price of crab meal.

Tillamook Bay, Oregon

Important here are salmon, crab, bottom fish, and oysters. Salmon scrap is taken by the Cedar Creek hatchery at Cloverdale. Some of the crab scrap is trucked to Astoria for reduction, and the rest is discarded. The fillet waste is utilized on the mink farms. About 35,000 mink are raised in this area. During the growing season of the mink, the ranchers utilize from 11 to 15 tons of fish scrap a day. About 5 tons a day are required during the rest of the year.

Because there is not enough fish scrap, the farmers have started a cooperative fishing operation and have installed a dock, fillet line, ice plant, and freezer. Even with these facilities, the supply of feed is not adequate. The ranchers, therefore, have had to obtain additional supplies from Astoria and Yaquina Bay.

Astoria - Warrenton- Hammond

The Astoria-Warrenton-Hammond area is the most important fishing center in Oregon. Here, salmon predominate, but tuna, bottom fish, and crab are becoming of increasing value.

Oil is extracted from the head and tail sections of the salmon. The eggs are used for fish bait and caviar. The rest of the viscera is used by the fish hatcheries.

Due to restrictions in Astoria, the rendering plants are located in the nearby Hammond and Warrenton area. Of the four plants, three are designed primarily for the reduction of whole pilchard, but waste from other species, especially tuna, are utilized when available.

The principal raw materials used by the fourth plant are fillet frames 1/ crab waste, grayfish carcasses, and scrapfish. One of the companies has stickwater processing equipment. Thus, the water-soluble materials, which were formerly discarded at this plant, are now saved.

The pilchard fishery in Oregon was started in 1935 when the state laws were changed to permit the use of pilchard for reduction purposes. Four plants were built at Coos Bay and three in the Astoria area. About 26,000 tons of pilchard were taken during the first summer of operation. This catch has never since been equaled. By 1939, the landings at Coos Bay had declined to an insignificant amount, and the companies there ceased operations. Since 1940, all of the landings have been made in the Astoria area.

Located in the Astoria area are two fish-liver plants, both of which are operated by companies also engaged in fish reduction. The principal raw materials are the livers of soupfin shark and grayfish. Other livers as well as viscera are also used. These include livers from lingcod, halibut, sablefish, rockfish, and blue shark, and the viscera from halibut, lingcod, rockfish, and sablefish. The soupfin shark was once even more important as a source of vitamin A than at present; but, due to the decline in its abundance, the landings of soupfin shark livers have greatly decreased.

Most of the fillet waste produced in the Astoria area is used by mink farmers. They come from Tillamook, Portland, and as far up the Willamette Valley as Eugene.

Columbia River, Washington

As may be anticipated, the fishery on the Washington side is similar to that in the Astoria area. The principal species of fish landed are salmon, smelt, shad, and albacore.

Willapa Harbor, Washington

In Willapa Harbor, just to the north of Astoria, oysters are one of the most important products. Crab, salmon, razor clams, and tuna are also important. The hatcheries use most of the salmon waste. Nearly all the rest of the scrap, including that from crab, is trucked to a reduction plant in Hoquiam. A plant at Bay Center grinds oyster shells for use in poultry feed.

1/ This is the portion of the fish that is left when the fillets have been removed from it. The expression is commonly used in this area.

A problem in this area is how to obtain an adequate supply of a suitable, inexpensive crab bait. Crabs show a marked preference for razor clams. Since the razor clams are in short supply and are a valuable market item, they command a high price. It is estimated that about one-fifth of the crab fishermen's income is spent for bait. Experiments have been made using other materials such as fresh-water mussels from the Middle West. The crabs, however, continued to prefer the more costly razor clams.

Grays Harbor, Washington

In recent years, tuna has contributed substantially to the income of the people in this area. Also important are crab, salmon, pilchard, razor clams, and oysters. During the war, Grays Harbor was the center of an important bottom-fishery. Since that time, however, landings have dwindled until, at present, the fishery is of little consequence. This change is attributed to high operational costs and the low price of bottom-fish fillets rather than to a decrease in the abundance of these fish.

Grays Harbor has long been a center of activity for the production of by-products. In earlier days, a whale reduction plant was located here, but the company has now gone out of business. Except for a few barnacle-covered pilings, all evidence of its existence has disappeared. In active operation, however, are three fish reduction plants, two of which are principally devoted to the manufacture of oil and meal from pilchard. The third, located in Hoquiam, utilizes fish scrap that is trucked from as far distant as South Bend and Westport.

Blaine, Washington

Most of the fish landed here are caught in the nearby Gulf of Georgia. The fishermen leave port in the morning and return on the evening of the same day. All scrap fish are saved and are usually left on the deck of the fishing vessel during the short haul to port. The disposal of the scrap fish is facilitated since a reduction plant is located on the same dock where the food fish are landed. Thus, the scrap fish, which are so often discarded at sea, can be brought to shore and utilized. However, much of the raw material used here for reduction comes by truck from Bellingham. Additional raw material is brought in by scow from a nearby salmon cannery.

Several years ago, Blaine was the location of a second reduction plant. However, it was never in successful operation because of the limited supply of raw material.

Bellingham, Washington

Most of the scrap in this area comes from bottom fish and salmon. Much of the bottom-fish scrap is utilized by mink farmers, some of whom are located in British Columbia. A large quantity of scrap is also taken by a reduction plant operator at Blaine, who has installed collection hoppers at several of the fish houses. Some of the salmon canneries have equipment for the extraction of head oil. Salmon skins for manufacture into leather are processed here.

For a short time during the war, a vitamin A plant was in operation. It closed, however, because of the difficulty of getting enough fish livers. A similar fate overtook a number of other vitamin A plants that were started in Grays Harbor, in Astoria, and in one or two other localities in Oregon.

Anacortes, Washington

One company in Anacortes serves as a base for a salt-codfish operation in the Bering Sea. Also located here are a number of salmon canneries and a crab cannery.

At one time a glue factory was located here, but it has since been removed to San Francisco. It is still of local importance, however, as the skins discarded in the codfish operation are sent to the glue factory at its new location.

There are two reduction plants. One of them had been closed for some time, but it has now been reopened under new management. It utilizes primarily grayfish carcasses, fillet waste, and scrap fish. The other reduction plant makes use of salmon-cannery waste. This firm operates a fleet of barges for collecting the waste from canneries located in Anacortes and the adjacent San Juan Islands.

One company here operates exclusively on the production of vitamin A oils from fish livers and viscera.

Seattle, Washington

The principal by-product industry in Seattle is the processing of livers for their vitamin A oil content. There are three large plants devoted almost entirely to this work. Perhaps more vitamin A oil is produced here than anywhere else in the world. Most of the halibut livers and viscera taken by American fishermen on the Pacific Coast ultimately arrive in Seattle as do also large amounts of grayfish livers. At one time, the soupfin shark was the source of an appreciable amount of vitamin A; but due to their present scarcity, the amount of vitamin A that they now contribute is relatively small.

Most of the fillet waste produced in Seattle as well as in nearby Everett is now being sold under contract to a fur breeder's cooperative. Local members of the cooperative pick up a considerable portion of the scrap directly. The remainder of the scrap is usually placed under refrigeration. If there is more scrap than the available refrigeration capacity can handle, the excess is taken to a reduction plant in South Seattle. The cooperative has recently built its own refrigeration facilities in Edmonds so that it is no longer dependent upon commercial cold storage facilities for the preservation of its scrap.

The operations of the cooperative are more complex than this simple description might indicate. Its success depends upon the immediate disposal of all scrap produced throughout the entire year. Close coordination of all facilities is required during periods of maximum production because the operators of the fillet houses can not permit the accumulation of waste. Complicating this problem are the seasonal feeding demands of the mink. Their greatest requirements are in the five months from July to November, whereas fillet waste is produced throughout the entire year. This means that most of the scrap available during December and in the months that immediately follow must be held under refrigeration until the kits are large enough to eat considerable quantities.

Before the advent of the cooperative, scrap was disposed of simply by dropping it through a hole in the floor of the fillet house on to a barge moored below. When loaded, the barge was towed to a reduction plant located on Whidbey Island. However, this plant is no longer operating and has recently been dismantled.

The operators of the fillet houses have installed loading facilities in order to handle the waste for the cooperative. Ten dollars a ton is paid for the waste to compensate for this and for the additional labor and bookkeeping involved. An additional $2.50 a ton is charged for hauling if the scrap is taken to the reduction plant.

Since the cooperative gets only about $5 a ton for the scrap sent to the reduction plant, it loses approximately $7.50 on each ton of scrap not used for mink feed. The local members of the cooperative do not raise a sufficient number of animals to utilize all the waste, and in order to minimize its loss on the excess, scrap is shipped to the members in Eastern Washington and Oregon, and in Idaho and Utah. The cost of the scrap mounts rapidly with the addition of shipping charges. For example, including the cost of the ice necessary for the preservation of the waste during transportation, the rate from Seattle to Salt Lake City is $43 a ton. For this reason, horse meat is competitive in price with fish scrap in the areas located away from the Coast. Packing-house waste and the head, feet, and viscera discarded in the factory preparation of poultry are also competitive in price with fish scrap. Consequently, only 10 to 20 percent of fish waste is utilized in the diet of mink in Utah, whereas up to 70 percent is used on the Coast.

The cooperative disposed of 9,300,000 pounds of scrap during the first 11 months of 1948. About a third of this was sent East, a third was used by the local mink ranchers, and the remainder was sent to the reduction plant. It is evident from these data that the shipments East are an important factor in making the whole operation feasible.

A number of other by-product industries are located here. Possibly chief among them are the caviar and fish bait manufacturers of which there are five. Also important are the fish hatcheries, both state and private. Three pet food manufacturers utilize over half a million pounds of scrap annually, and this does not include the relatively large amounts of fish meal used. A small amount of selected salmon waste is bought here by pharmaceutical manufacturers located in the East.

Some of the by-product firms organized in this area have not been successful. Shortly after the first world war, a company in Edmonds made leather from shark skins. It later went out of business because of difficulty in getting the skins. About eight years ago, a company in Tacoma attempted to make meal from grayfish carcasses. It also failed because of a lack of raw material.

Conclusions

Very little fish scrap is being discarded in Washington and Oregon. The small amount not utilized is either in an area where the supply is inadequate to support a commercial operation, or else the material is of such a nature that it does not command a market. Companies have failed because the supply of waste has been insufficient. Others have lost money on the production of materials not in demand. Anyone who intends to enter the field of by-products should, therefore, make a thorough survey of the source of supply and the market for the finished product.

The by-products industry is not static. Changes are taking place, and the field is becoming increasingly competitive. Fish waste, in earlier years, was thrown away. Later, it was utilized only by reduction plants. Now it is in demand for reduction purposes and for mink feed and other uses. With few exceptions, the operations have not produced appreciable revenue, and many firms have operated largely on a marginal basis. For this reason, there is a continuing and increasing pressure to find more remunerative uses for the waste. The problems to be solved are not easy; but with a rapid acceleration in technological knowledge and the demands of a growing population, further changes are inevitable.

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